Talk 2: Experimental Work

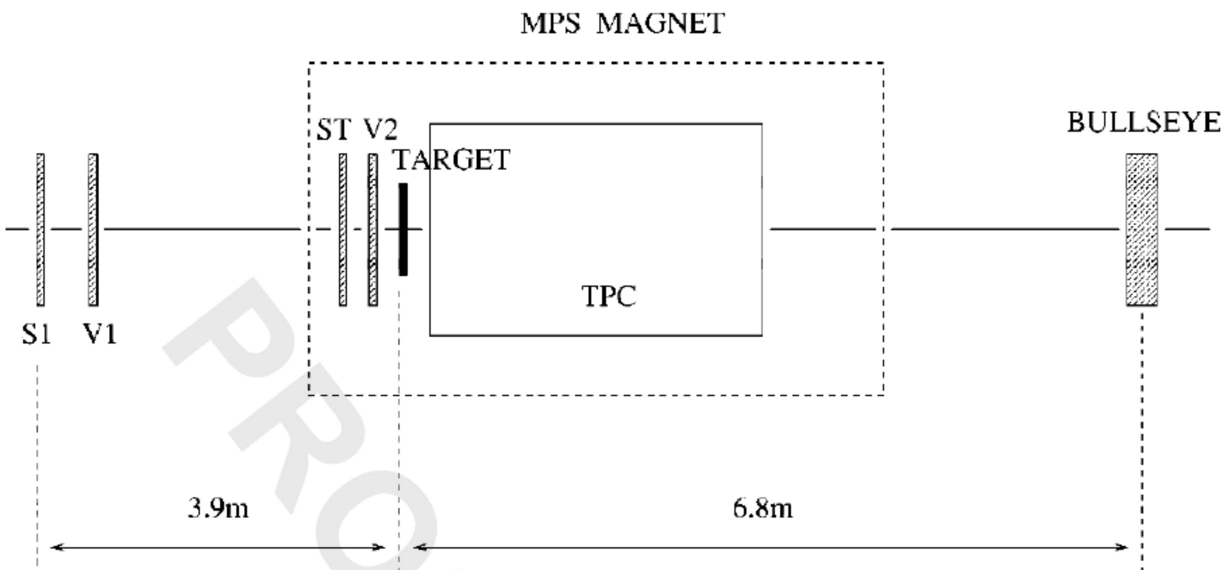
Oxford 11/01

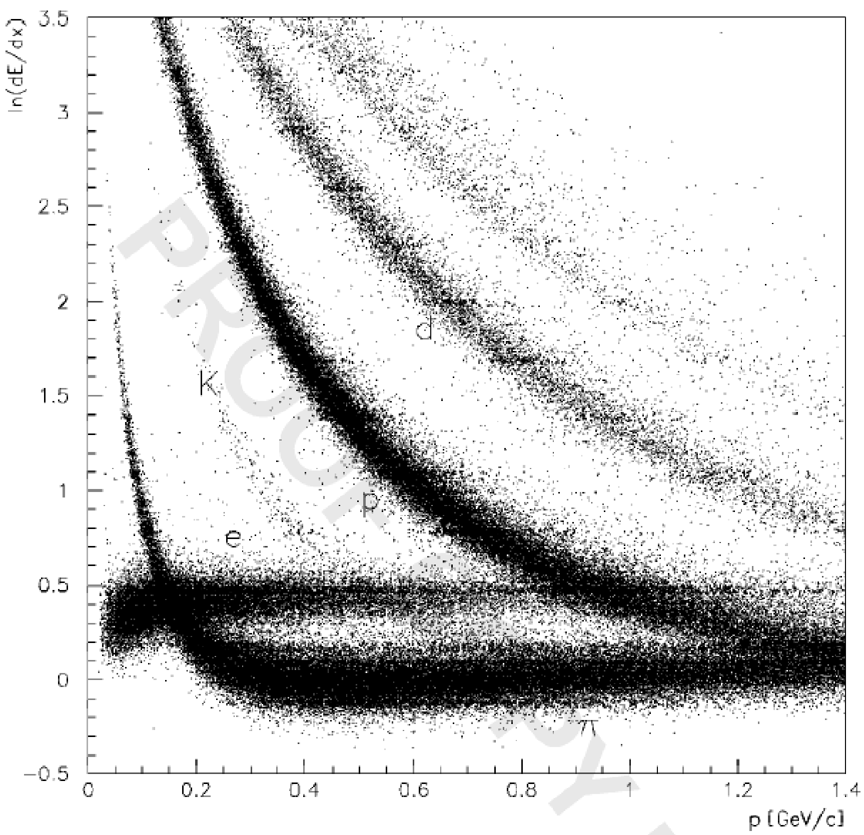
R. B. Palmer

- Pion Production
- BNL Target Exp
- CERN Target Exp
- CERN RF
- CERN/Cornell SC RF
- Fermi RF
- Absorber
- Muscat
- MICE

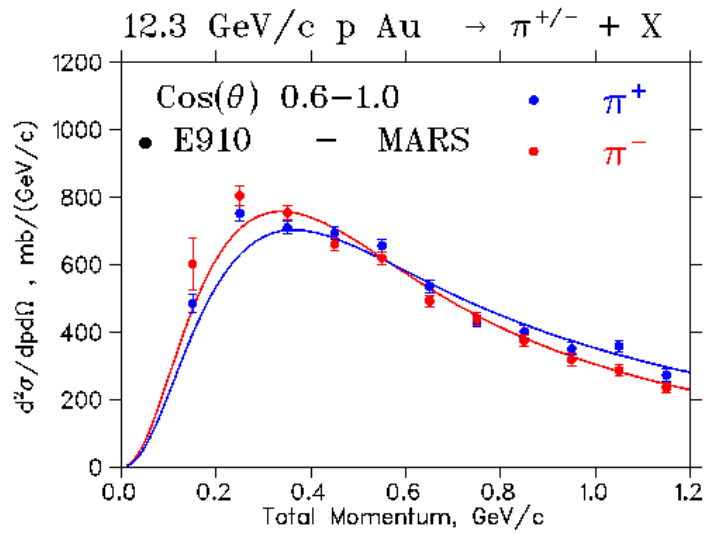
BNL Pion Prod. Exp. (E910)

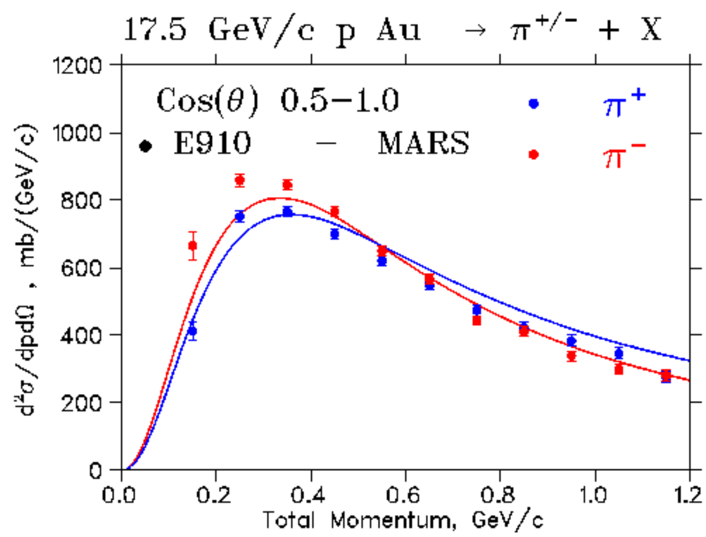
p: 8, 12, & 17 GeV π: 0 to 45 deg.





Recent Analysis:



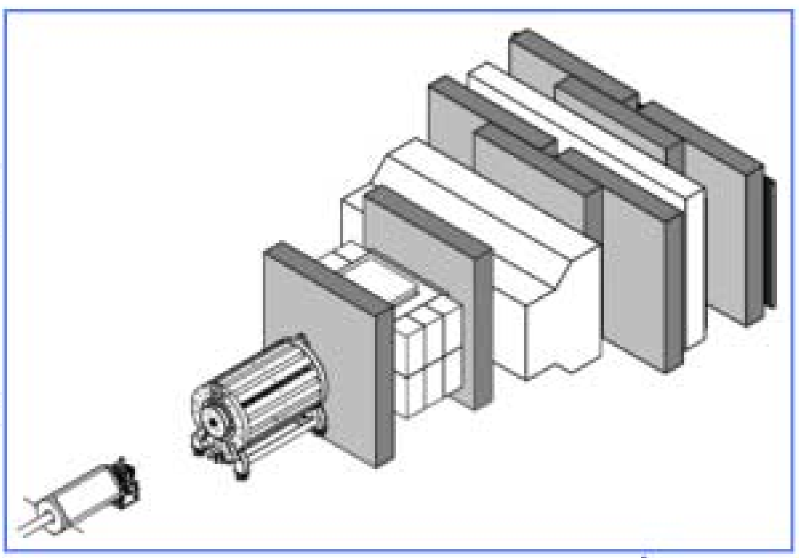


CERN HARP
Pion Production Experiment

π+ and π- production:

- **for various target materials and target lengths**
  - ⇨ optimum choice of target material and geometry
- **for proton energies between 2 and 16 GeV**
  - ⇨ precise estimation of the difference between high and low proton energies
- **in all directions**
  - ⇨ precise estimation of backwards production of pions

The HARP Spectrometer: full acceptance is assured by a TPC and a forward spectrometer consisting of a dipole magnet with tracking chambers. Particle identification is defined by dE/dx, a threshold Cherenkov counter, time of flight and an electron and muon veto.

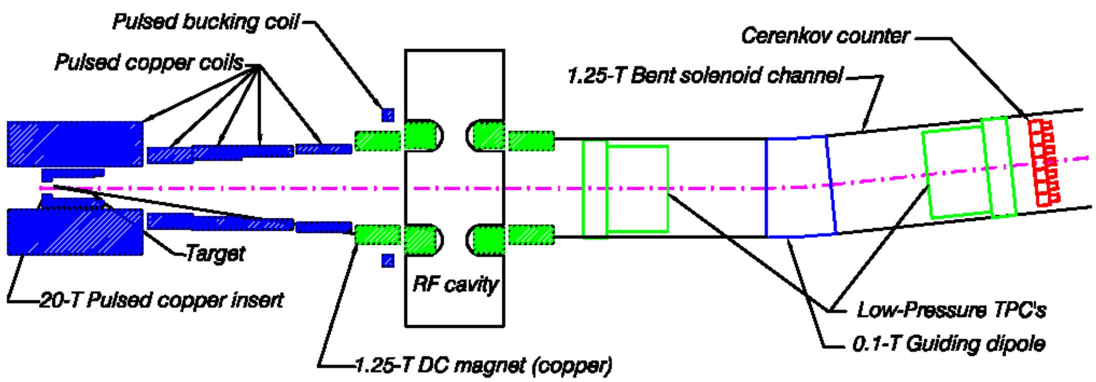


BNL Target Exp. (E951)

Spokesperson K. McDonald,

- **Project Manager H. Kirk**

Original Full Proposal

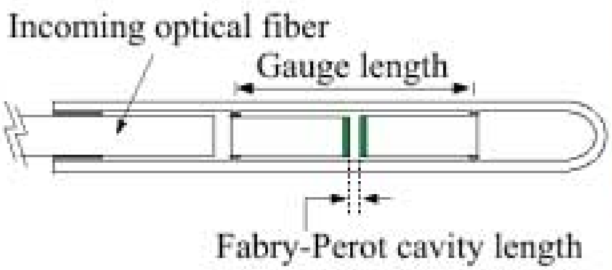


Phase 1: Beam on Targets

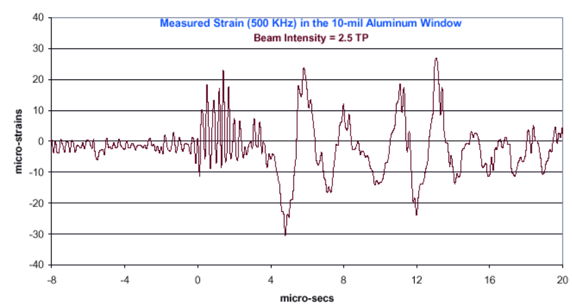
Run in April at AGS

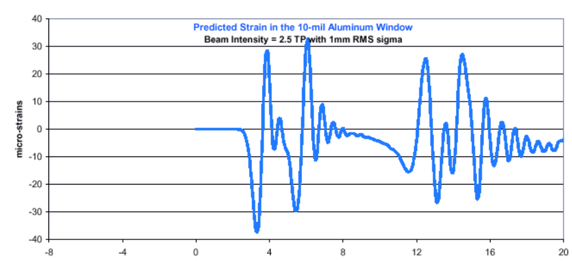
Target Box

Solid Target Strain measurements with beam:



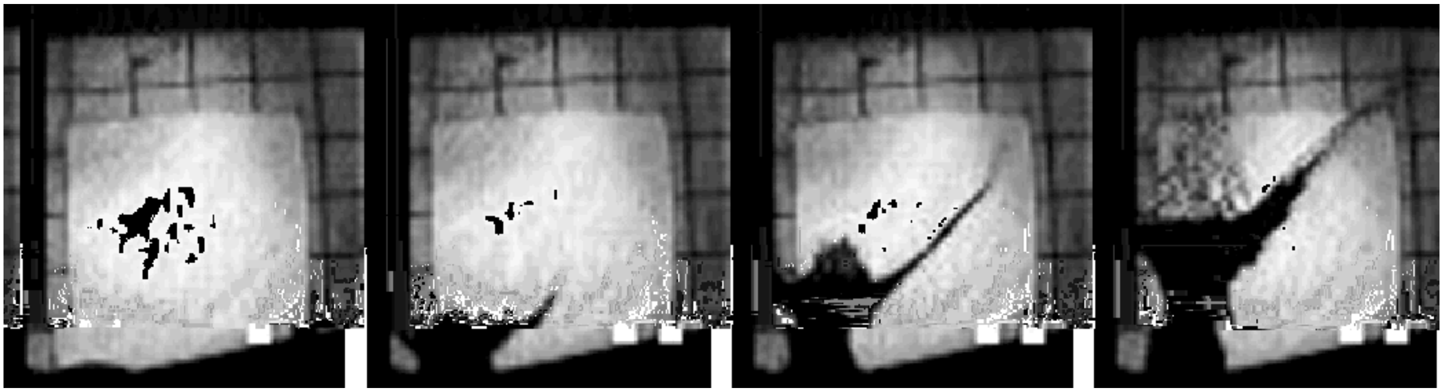
Qualitative agreement with simulations



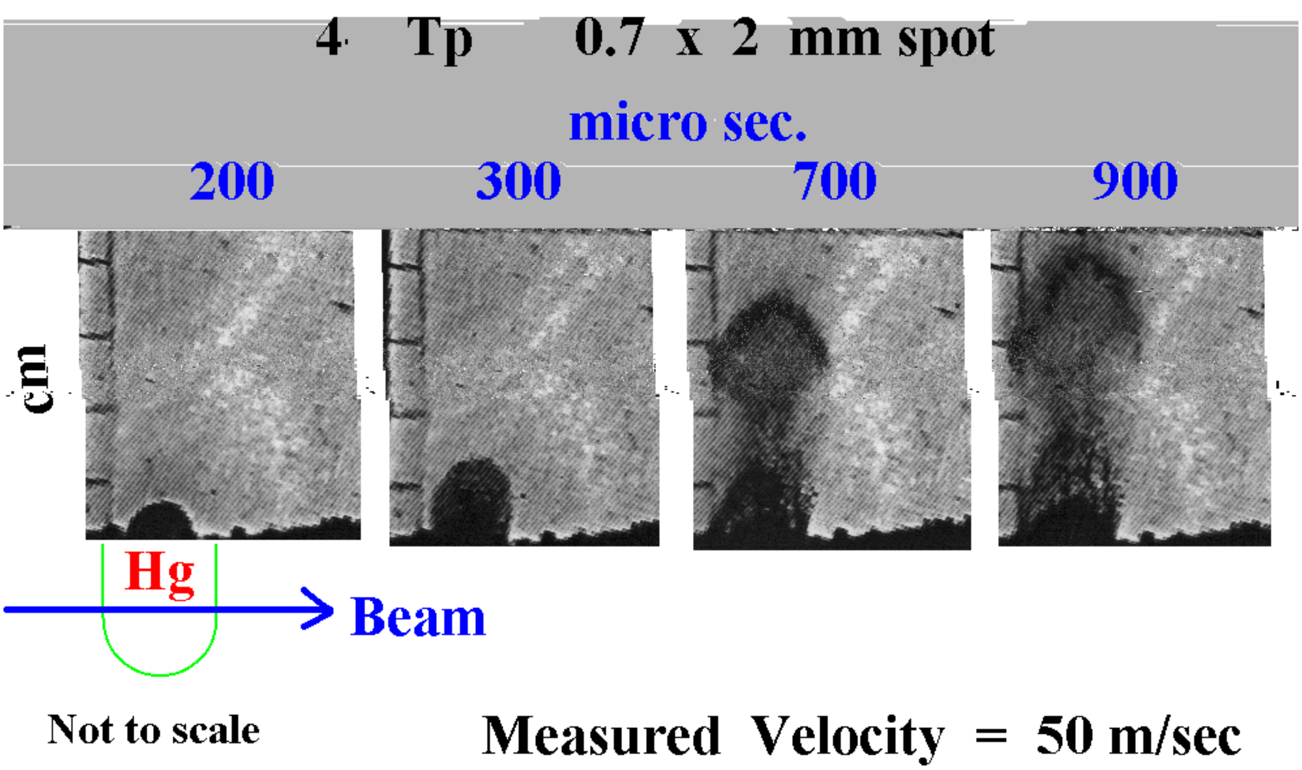


CERN Hg Trough in beam

First Shot (cup full)

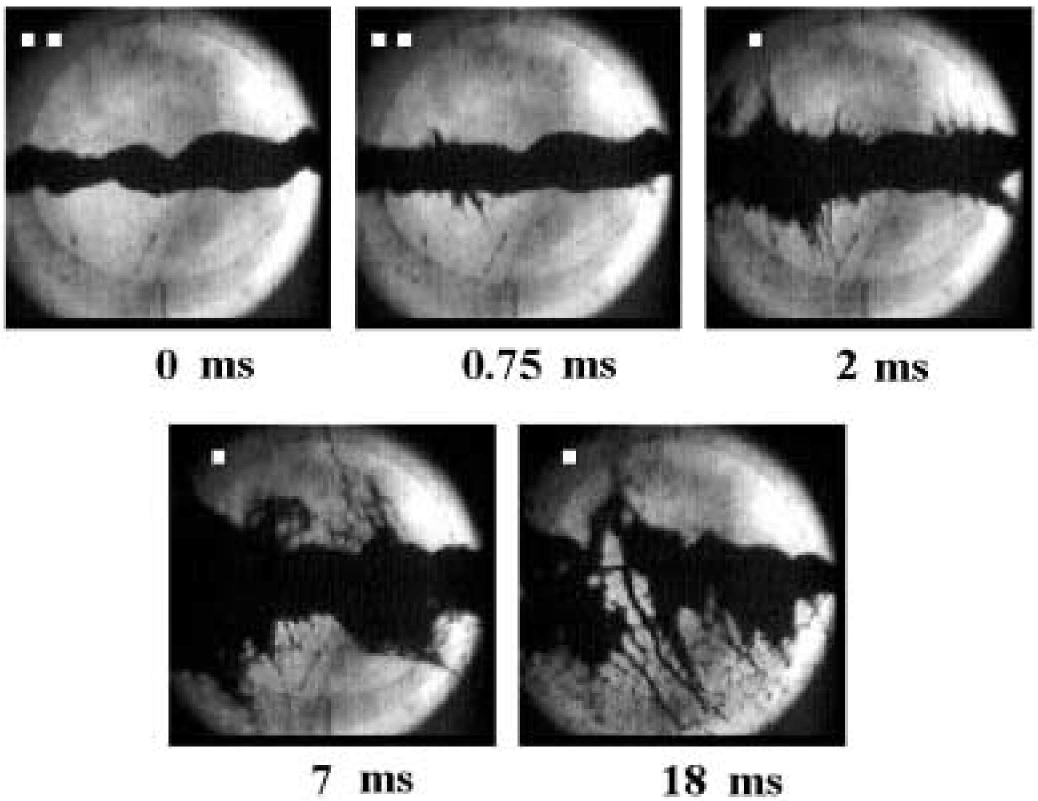


Faster camera, but not full



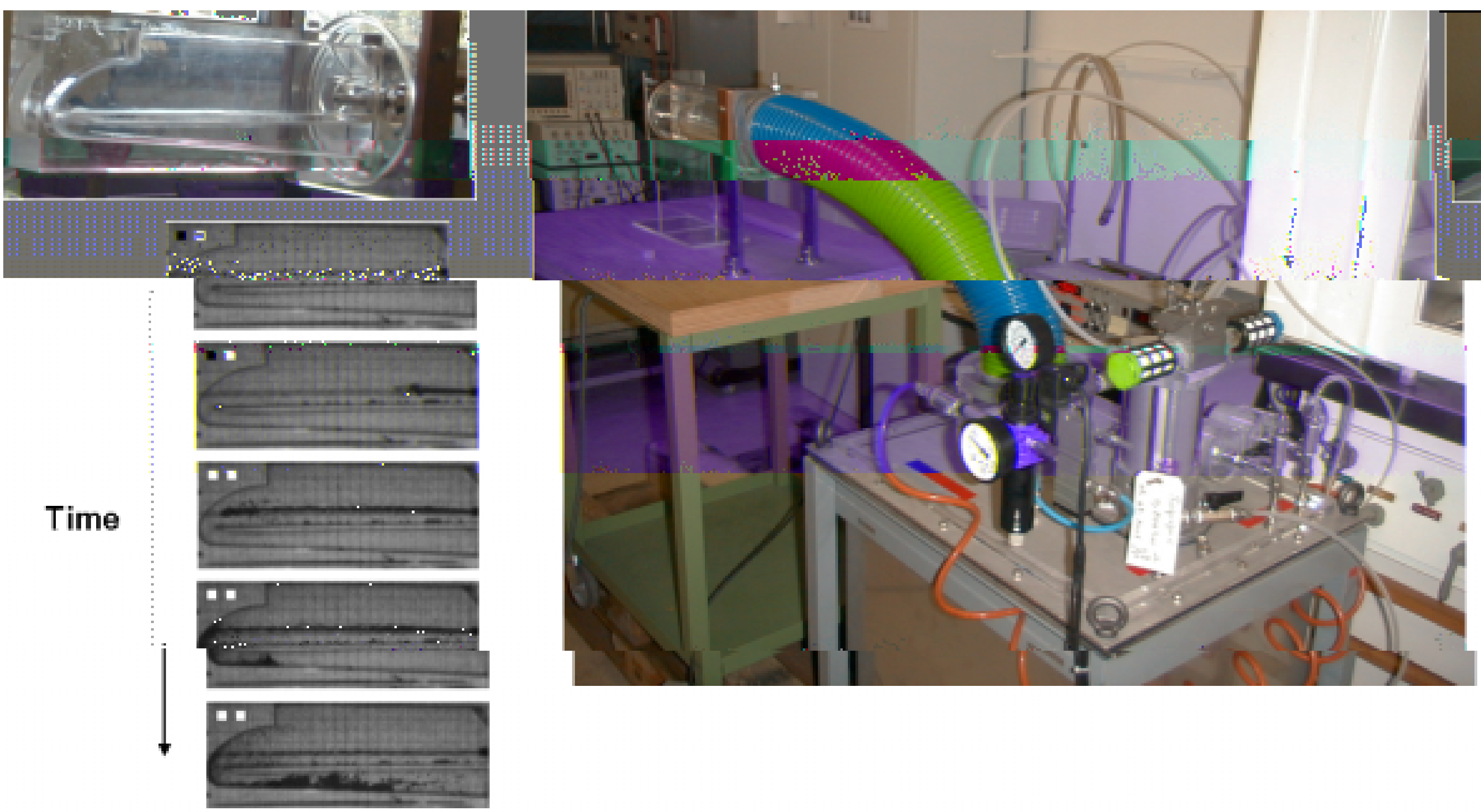
BNL Jet in beam

1-cm-diameter Hg jet in 2e12 protons



- Jet vel 2.5 m/sec, 1 cm dia.
- Beam:
  - 2-4 10^{12} ppp 16 10^{12}
  - 0.7×1.9 mm 1.5×1.5
  - 1/6 - 1/3 energy density of 1 MW
- Delay 40 micro sec : bubble chamber
- Droplets 50 m/sec $\rightarrow$ 10 m/sec : air
- No disturbance upstream

CERN Hg Jet in lab



At CERN and BNL: jet is turbulent and uneven due to high Reynolds Number

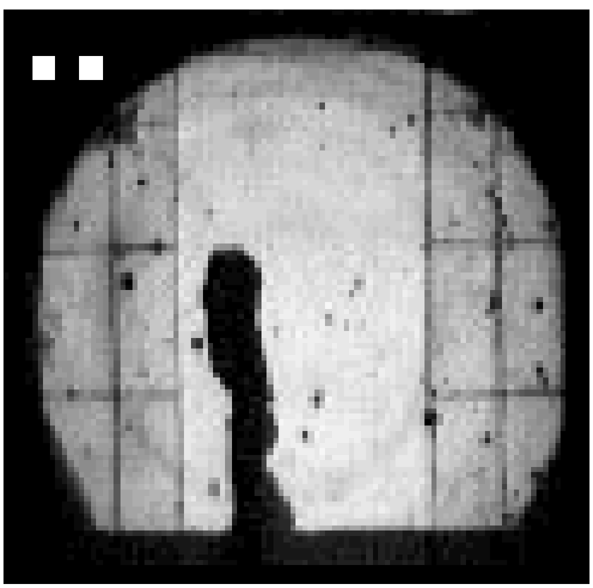
It will get worse (CERN jet small, BNL jet slow, R $\propto rv$)

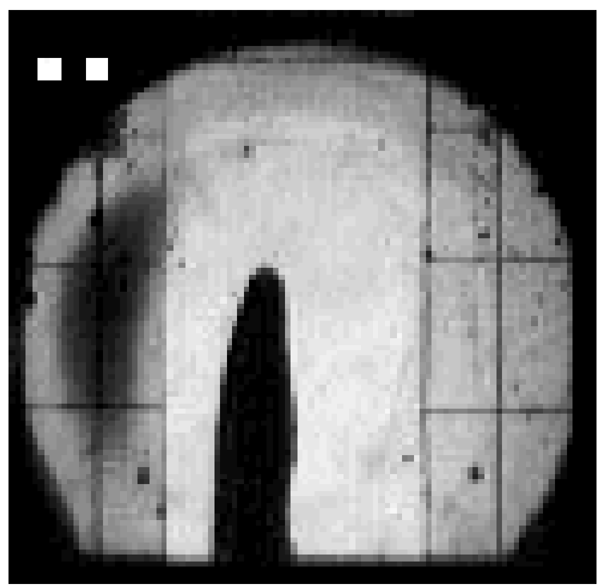
Need nozzle design

Magnetic Field may stabilize:

Jet entering B at Grenoble

1 cm diam. jet, $v = 4.6$ m/s, $B = 0$ T; $v = 4.0$ m/s, $B = 13$ T:





$\Rightarrow$ Damping of surface tension waves (Rayleigh instability).

CERN RF

88 MHz Cavity will be modified and coils added

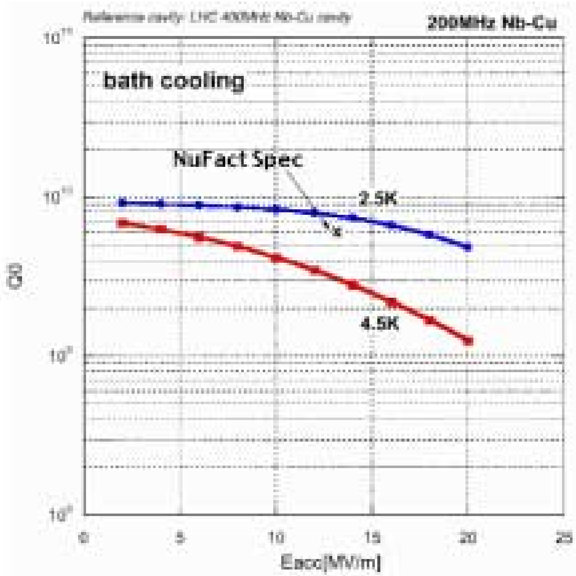
Will it get 4 MV/m, as specified in CERN design ?

SC Cavity work at Cornell/CERN

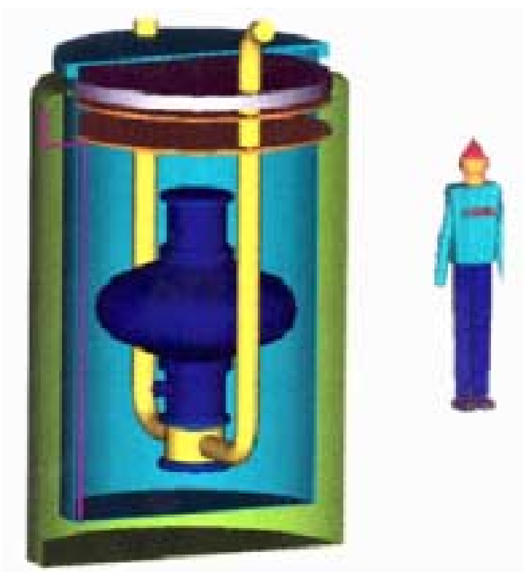
Cavity under construction at CERN

- Will it get 16 MV/m ?

Q scaled from LHC:



Test pit under construction at Cornell



RF at LBNL & Fermi

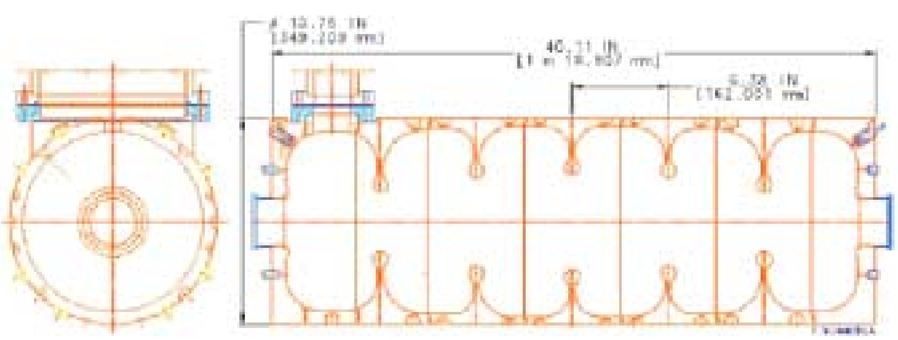
Fermi Lab G RF Tests

Gradient and dark current ?,
but at 800 MHz (for collider)

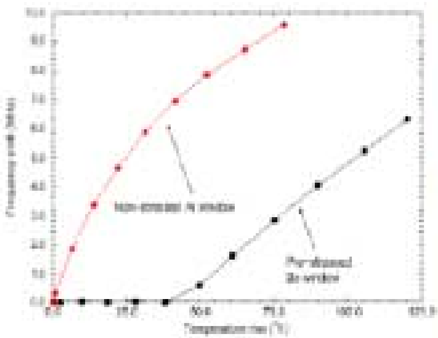
Cave

SC Solenoid

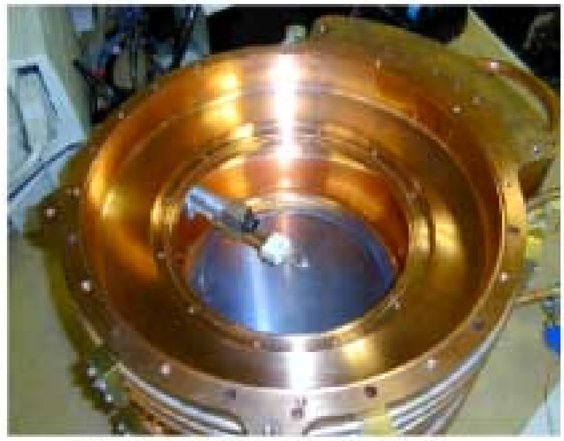
805 MHz Open-Cell Prototype



LBNL Be Foil tests with heater



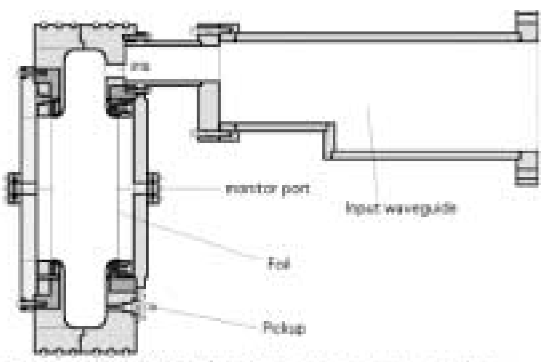
Measured temp. threshold



Low-power test model

Testing has validated expected foil behavior:

Closed 805 MHz Structure



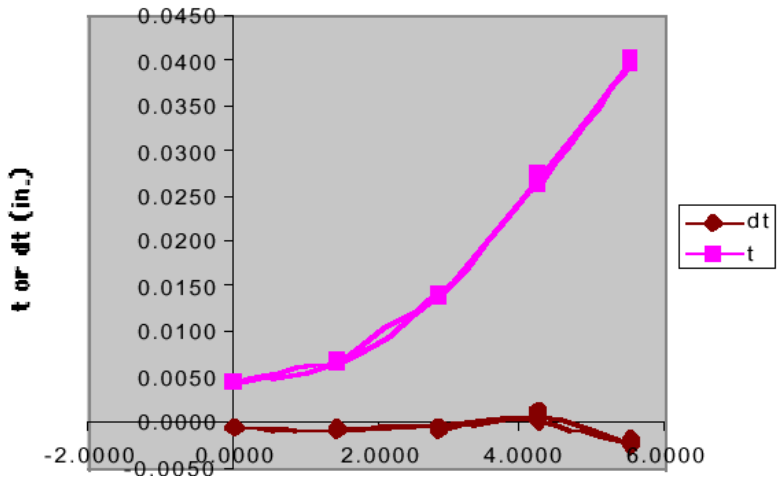
LBNL 805 MHz high power test cavity

Parts being made at U.Miss.

Parts being brazed at Alphabraze

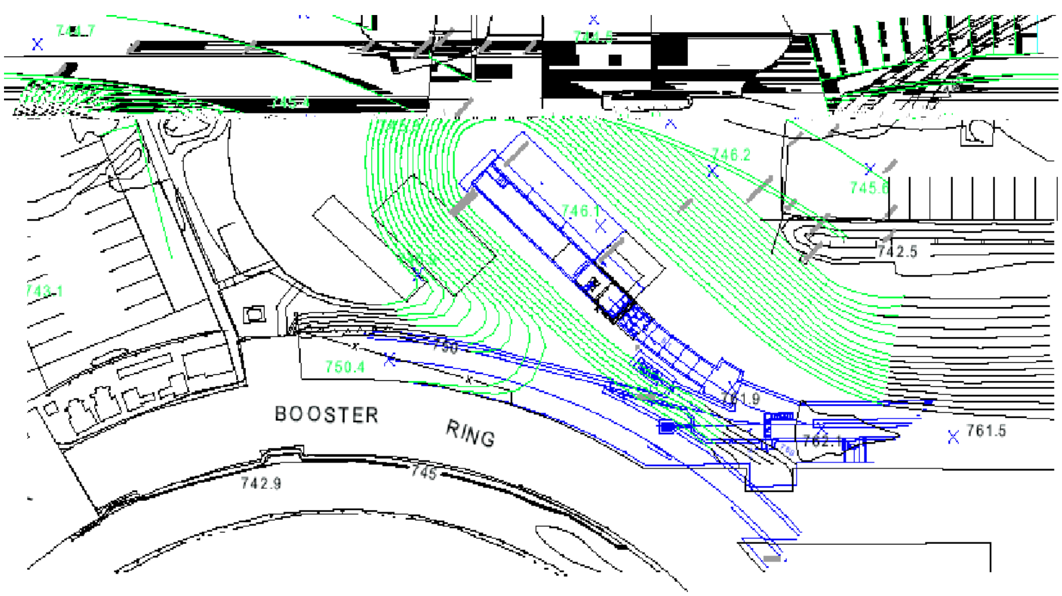
Foils will be tested at high field

H_2 Absorber R&D at IIT & Fermi



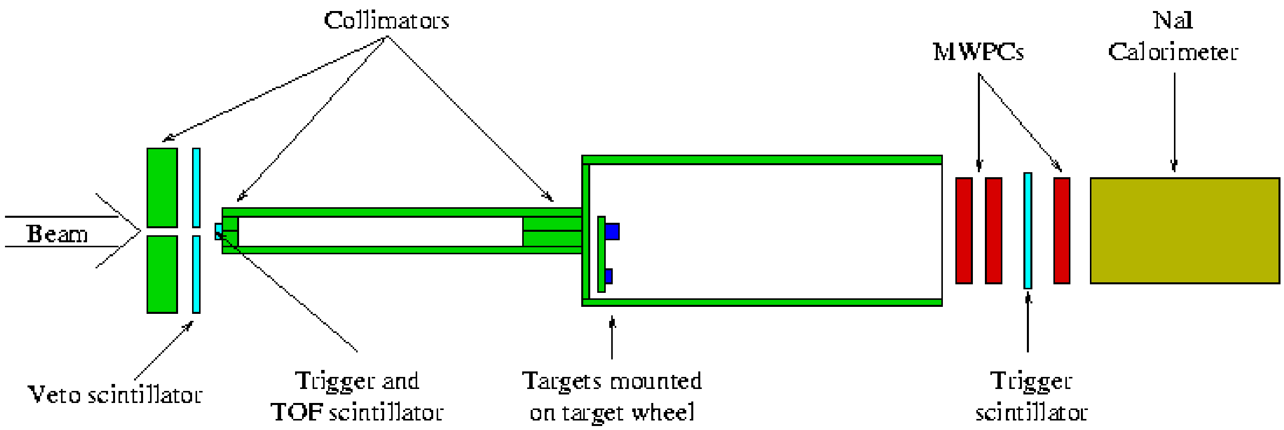
New Area with Linac Beam for H_2 Absorbers & 200 MHz RF

Under Construction



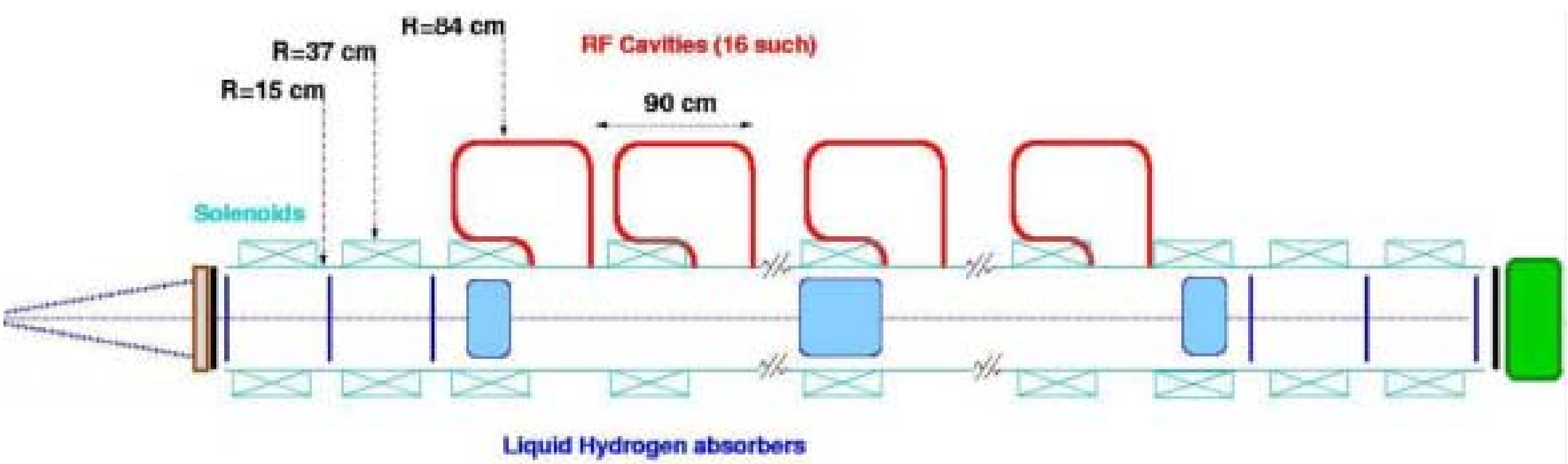
Triumph MUSCAT

Study of muon scattering



Muon International Cooling Experiment (MICE)

Original CERN 88 MHz Design



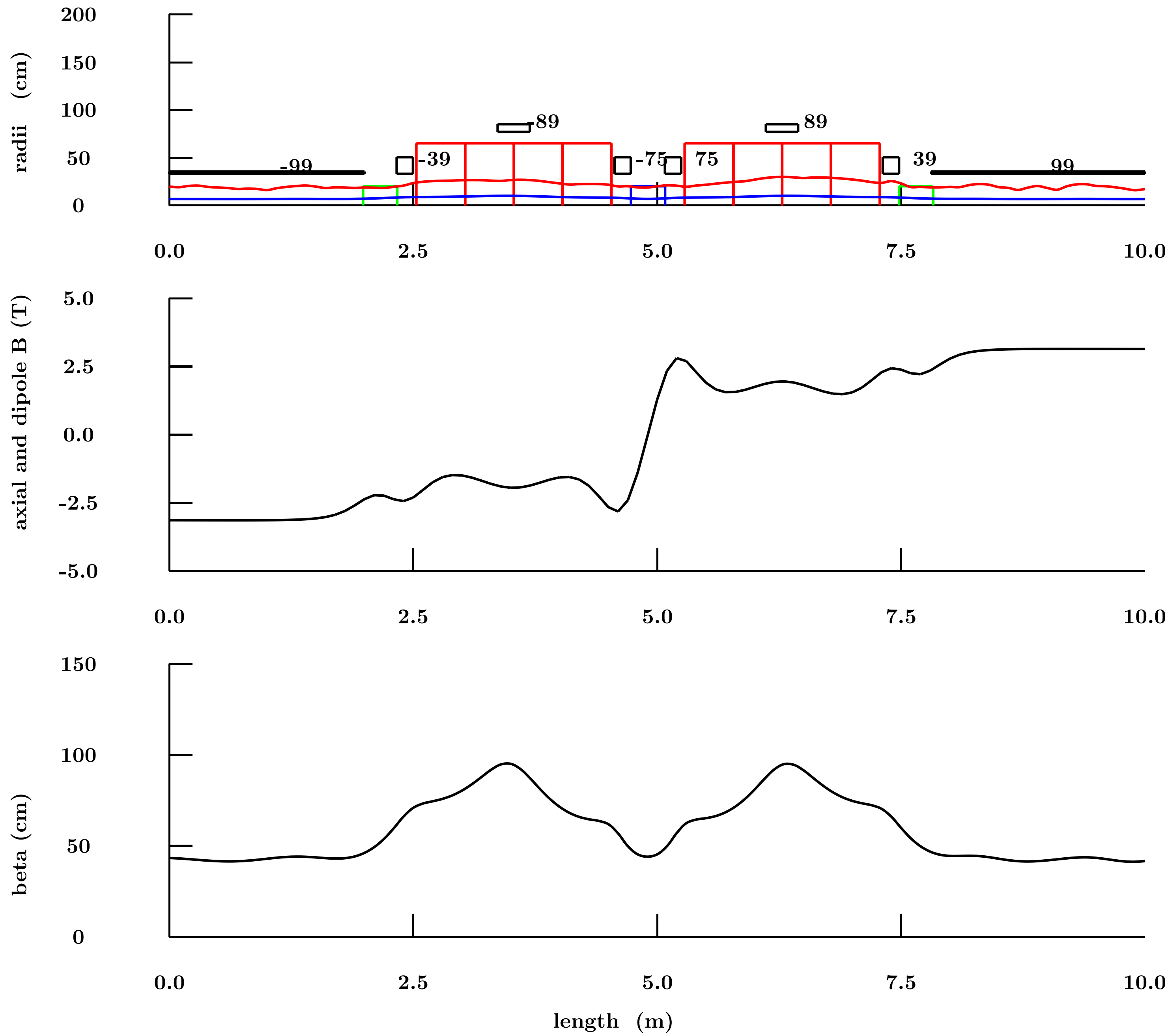
Use low intensity muon beam

Measure directions and momenta of tracks before and after cooling section.

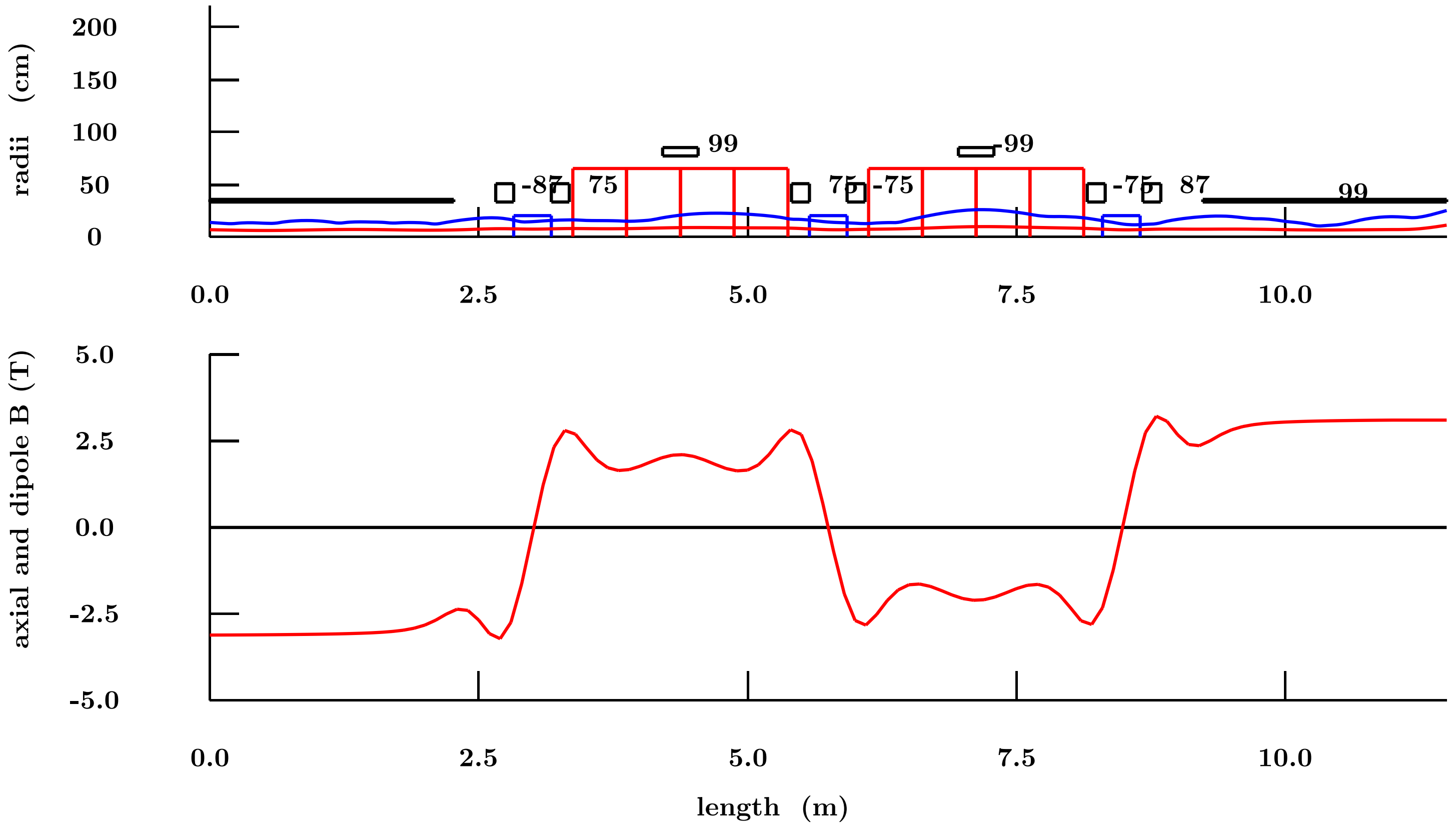
Form "beam" off line and study changes in emittance.

Using Study 2 200 MHz

Geometry A: 1.5 cells

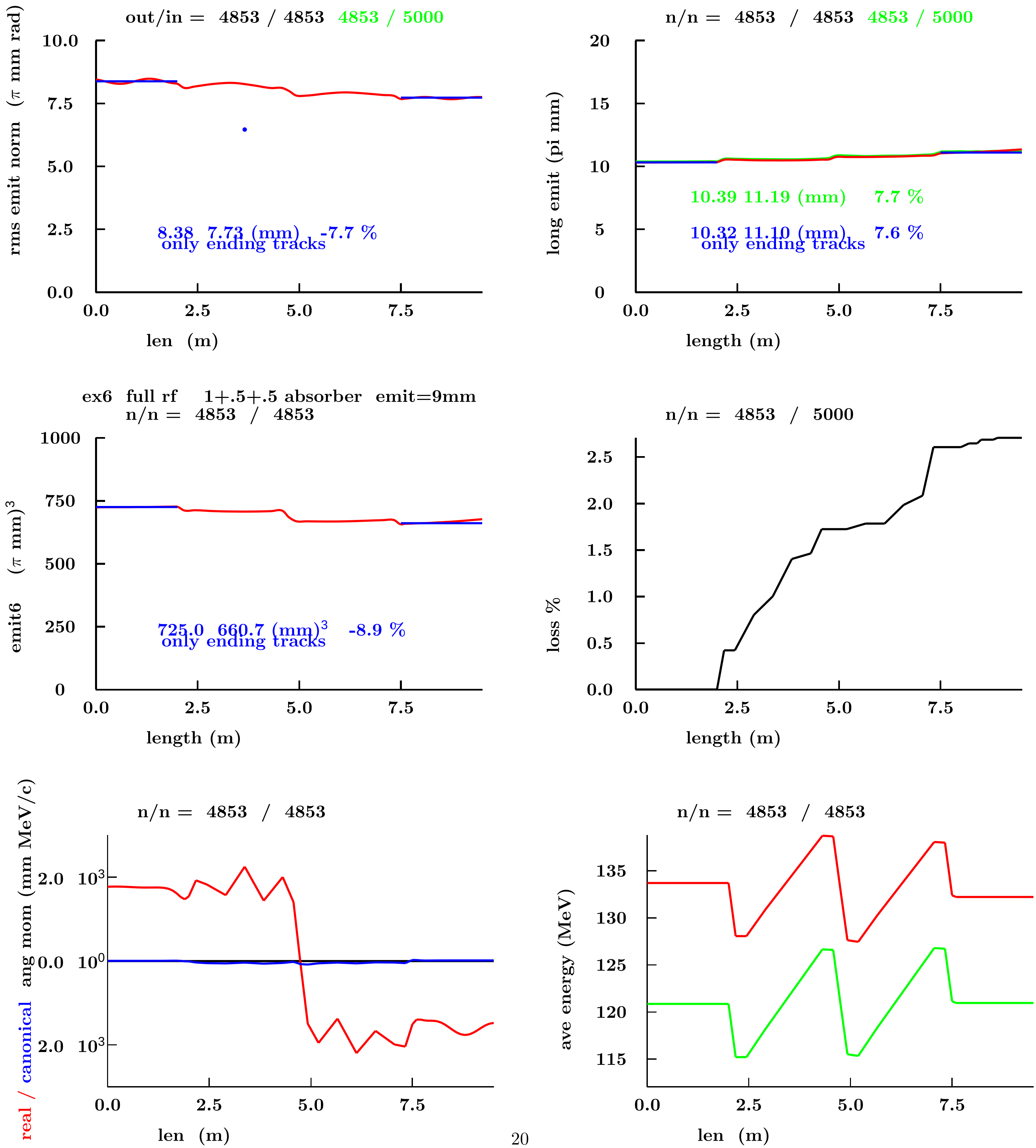


Geometry B: 2.5 cells



Prefered because more like real lattice, but more expensive and harder to match into measurement solenoids.

Geom A 1/2 + 1 + 1/2 abs



Input used

particles		5000
uncorrelated momentum	MeV	200
Transverse emittance	π mm	9
Longitudinal emittance	π mm	11
uncorrelated dp/p	%	7
rms ct	cm	9
mom-amp^2 correlation	GeV/c	.34
ct-angmom correlation	GeV^{-1}	-35
ct-dp/p correlation	m	1.14

Summary of ICOOL simulation

	all tracks	ending tracks	true*	
Transverse emittance change	-13	-7.7	-9.2	%
Longitudinal emittance change	+7.7	+7.6	+4.0	%
6-D emittance change	-18.9	8.9	-13.9	%

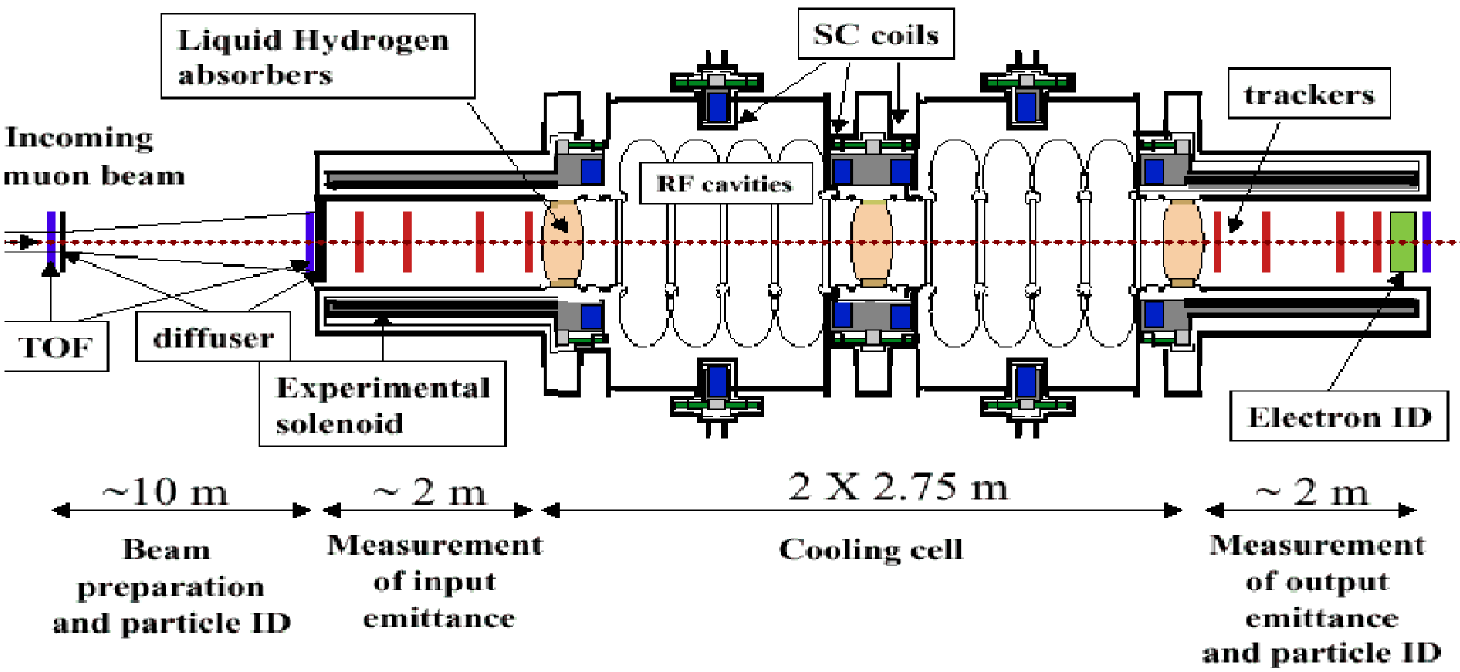
$*$ From continuous cooling, i.e. ideal input matching

Run Options

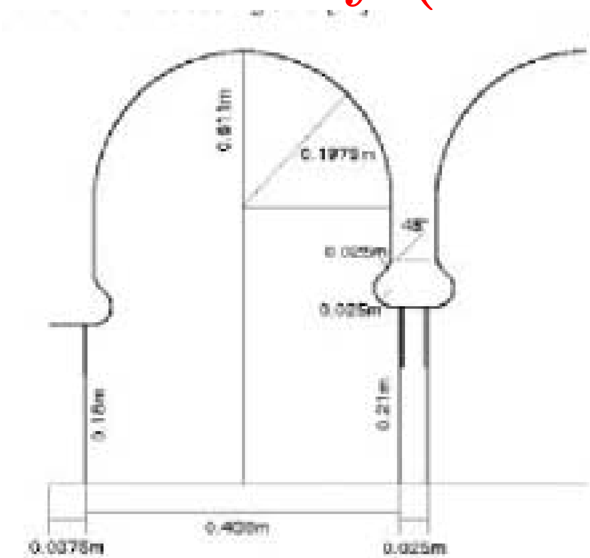
	$E_1 = E_2$?	$n_{absorbers}$	rf grad MV/m	rf phase deg	$\Delta\epsilon_\perp$ %	rf Power MW	simulated
a	yes	1/2+1+1/2	15.5	30	8	32.3	yes
b	no	1+1+1	15.5	30	12	32.3	
c	yes	1/2+1+1/2	8.7	90	2	10.3	yes
d	no	1+1+1	8.7	90	12	10.3	
e	yes	0+1+0	7.7	30	4	8.1	yes
f	no	1+0+1	7.7	30	8	8.1	
g	yes	0+1+0	4.4	90	4	2.6	
h	no	1+0+1	4.4	90	8	2.6	
i	no	0+1+0	0	0	4	0	
j	no	1+1+1	0	0	12	0	

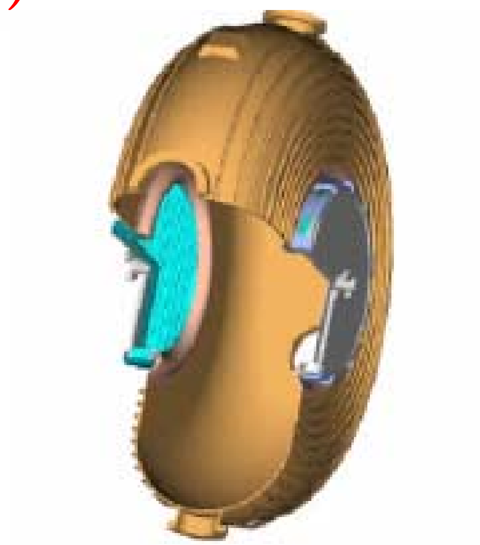
Start of Engineering

This is geometry A, but B
is still prefered

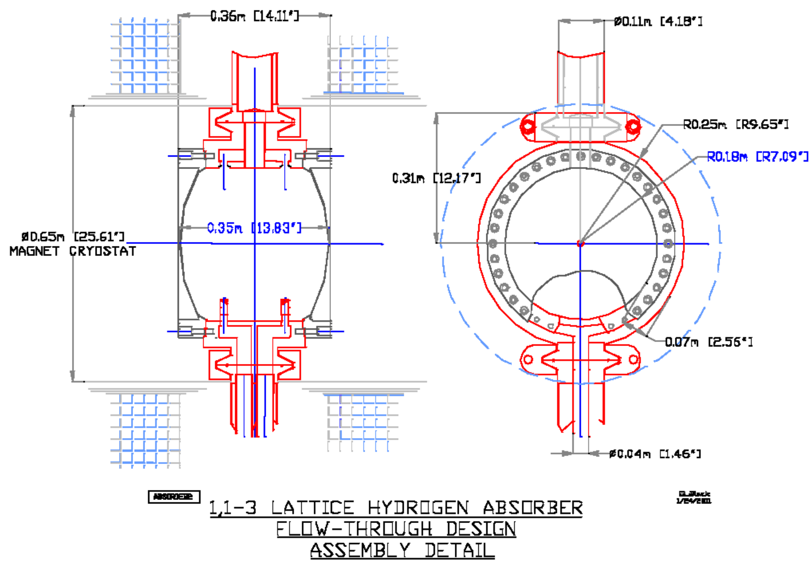


RF Cavity (LBNL)

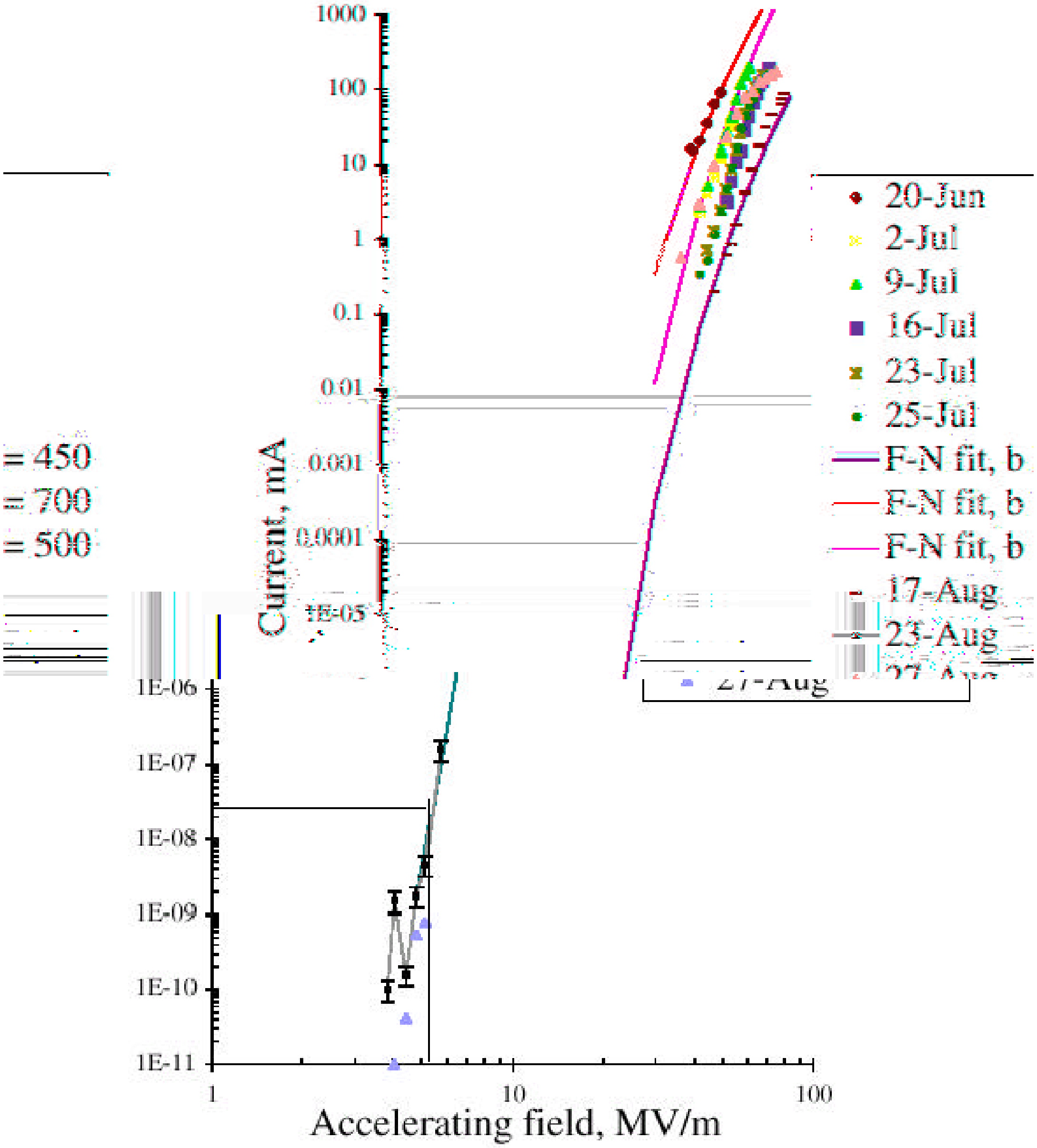




Liquid H2 Absorber (ITT)



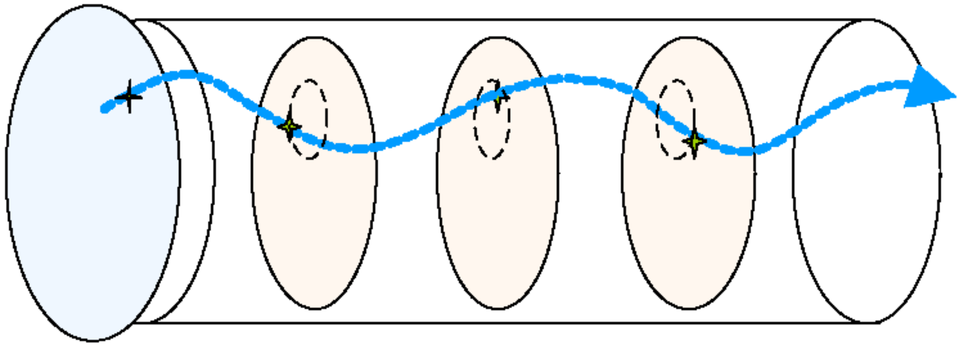
Dark Current Observed



Assuming X-Rays $\propto$ dark current
This is several orders of magnitude too high for the detectors.

Investigate polishing, cleaning etc
Use lower gradients
Use more X-Ray resistent detector.

Detector in Solenoid .



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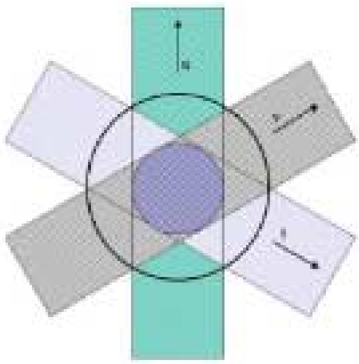
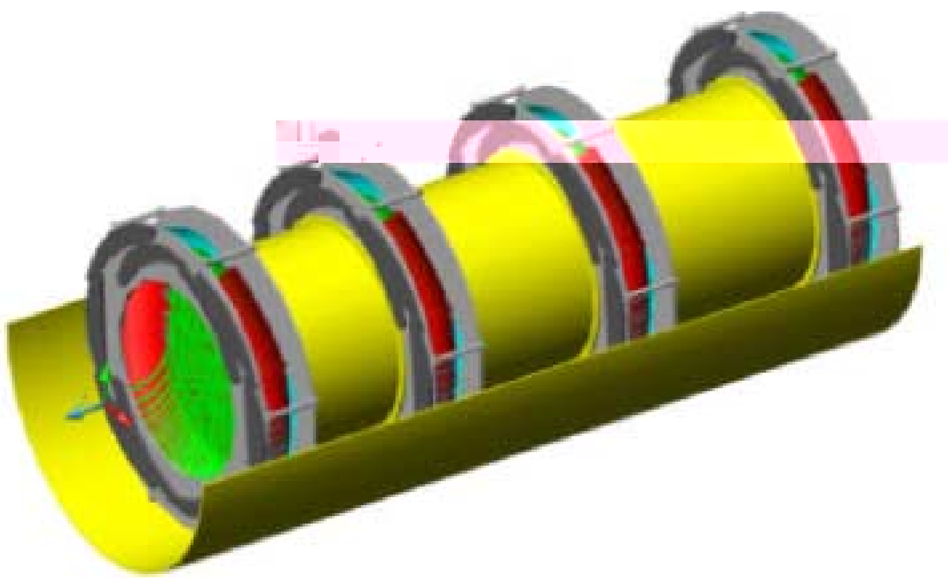
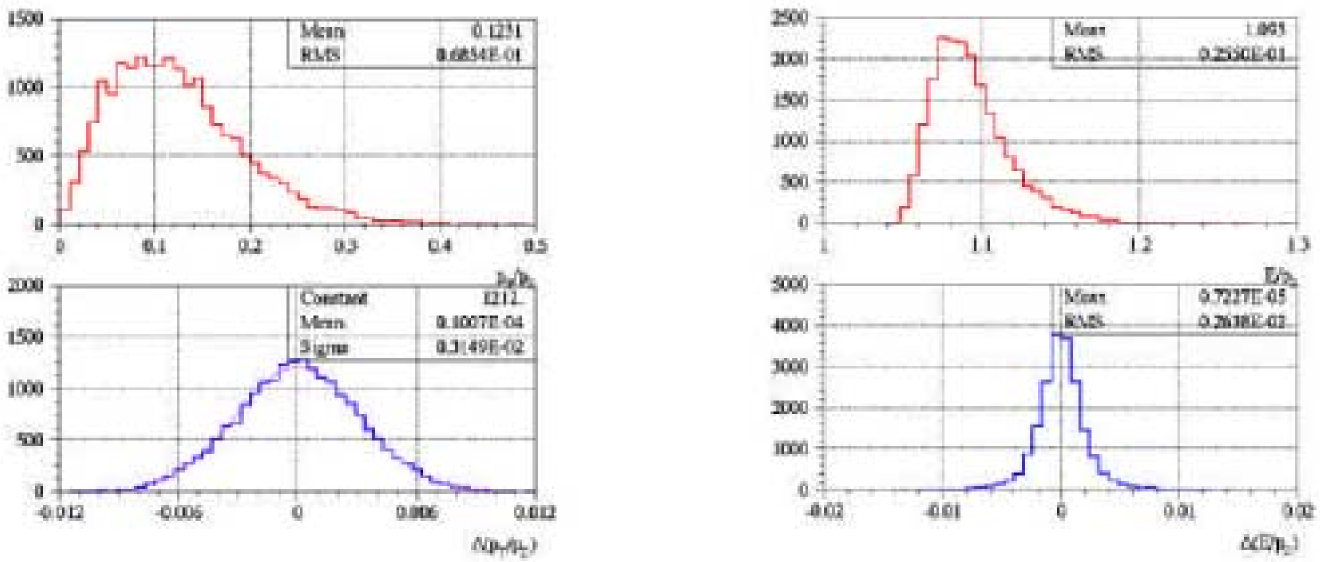


Planes of scintilating fibers

.



Resolutions



$$\frac{\delta(p_\perp)}{p_z}) = 0.3\ 10^{-2} \qquad \frac{\delta(p_\parallel)}{<p>}) = 0.25\ 10^{-2}$$

If systematics = 10% of sigma, rms θ=0.1 rad, rms dp/p=7%, then, neglecting errors in dx and dt:

$$\delta(\epsilon_{x,y}) \approx 0.3\% \qquad \delta(\epsilon_z) \approx 0.4\%$$

c.f. expected transverse cooling 8-12 %, and longitudinal heating $\approx$ 4%. So the contribution from these will be less than 10% of the expected signals.

In addition, I estimate:

$$\delta(x, y) \approx 0.2(\mathrm{mm}) \qquad \delta(t) \approx 100(psec)$$

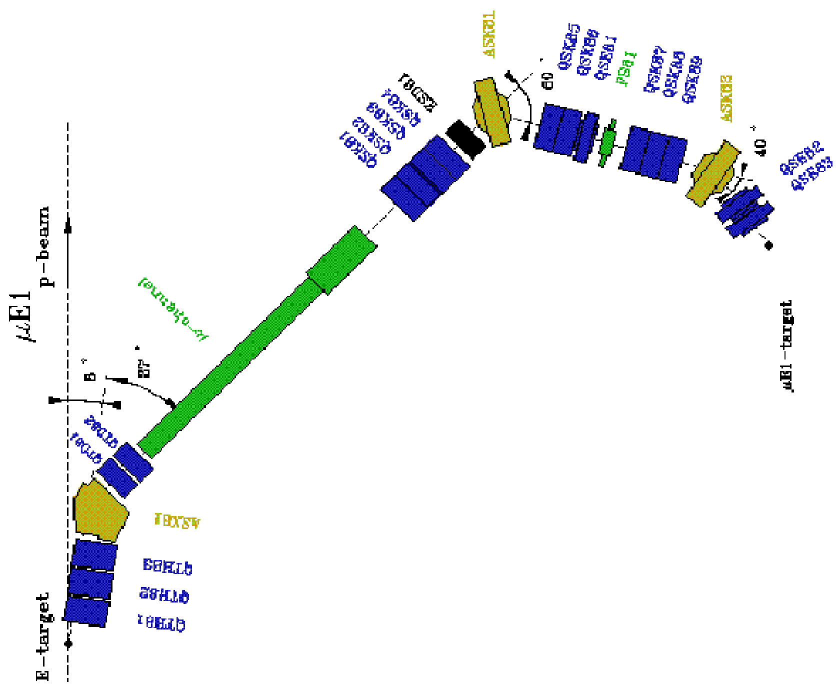
Again, if systematics = 10% of sigma,
$\sigma(x, y)$ =**10 cm,**
$\sigma(t)$ = **400 (psec), then from these:**

$$\delta(\epsilon_{x,y}) \approx 0.02\% \qquad \delta(\epsilon_z) \approx 2.5\%$$

Again, c.f. expected transverse cooling 8-12 %, and longitudinal heating $\approx$ 4%.
So the contribution from position measurement is negligible, but that from the time is over 50% of the expected signal ! i.e. we can measure 5D cooling to better than 10%, but 6D cooling only if the systematcs are much better than 10% of the timing scatter.

LOI sent to PSI, which has suitable beam

Beam & Layout at PSI



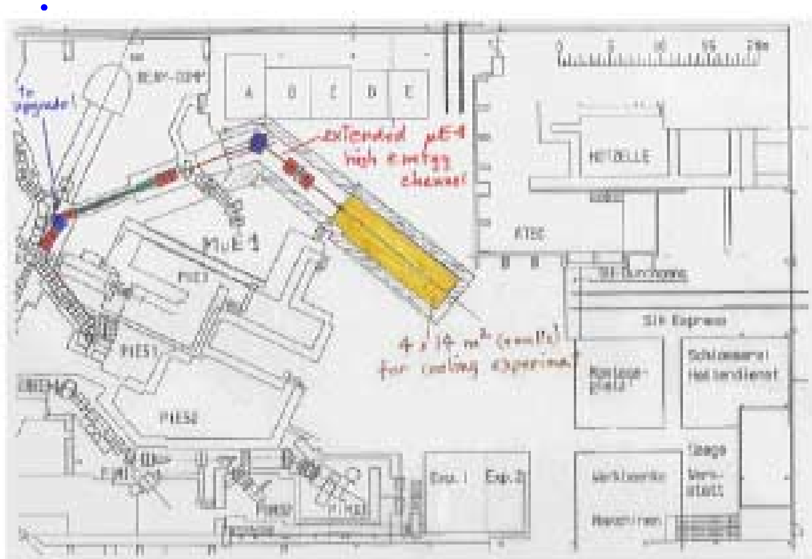


Figure IV-5.3 Possible implantation of the MICE experiment in the PSI experimental hall.

LOI also sent to RAL, but RAL beam is not yet for muons, so needs to be modified

Beam at RAL

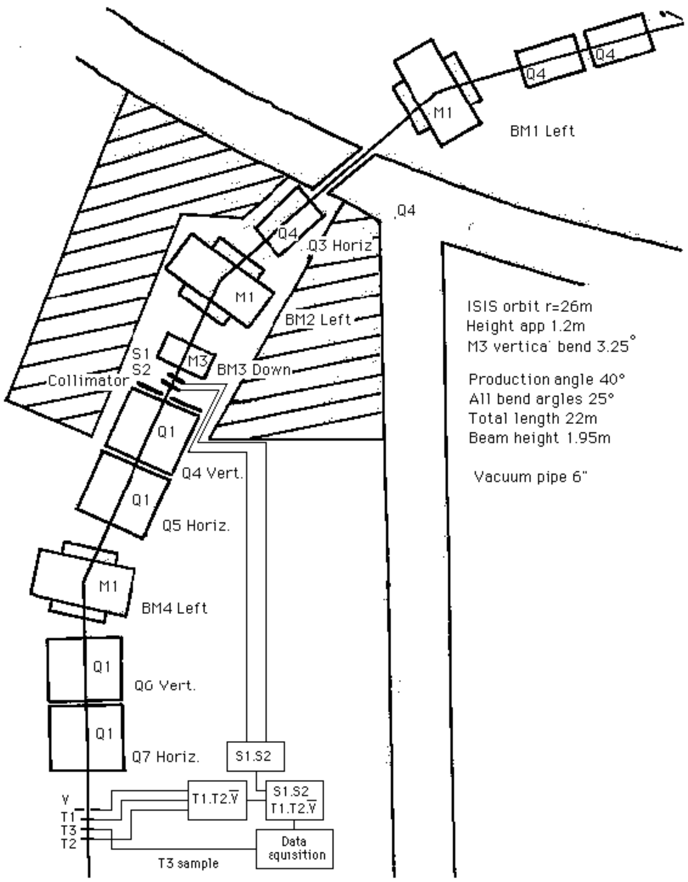


Figure IV-5-5 the existing High Energy Physics beamline at ISIS (RAL).

COSTING OF $\mu-$ICE

Item	fixed cost	Add. Unit cost	cost for: 1 cavity 4 MW	1 cavity 8 MW	2 cavities 4 MW	2 cavities 8 MW	2 cavities 32 MW
COOLING CELL							
RF Cavities							
4 cell cavity 200 MHz	0.3	0.5	0.8	0.8	1.1	1.1	1.1
RF POWER:							
CERN-refurbish		0.2	0.2	0.2	0.2	0.2	0.2
FNAL-refurbish (?)		0.2	0	0.2		0.2	0.2
NEW diacron tubes	1	1.2	0	0	0	0	8.2
MAGNETS							
focus pair	1	1	3	3	4	4	4
coupling loop	1	1	2	2	3	3	3
Liquid H2 absorbers	0.5	0.1	0.2	0.2	0.3	0.3	0.3
H2 safety	2		2	2	2	2	2
Total for cooling cell US $ (US costing)			8.2	8.4	10.6	10.8	19
cooling DE (On crest)			11.5MV	16 MV	16 MV	23 MV	46 MV
Approx. $\Delta\varepsilon/\varepsilon$ (%)			5%	7%	7%	10%	20%
DIAGNOSTICS							
detector solenoids		1	2	2	2	2	2
Detectors		2	2	2	2	2	2
Total diagnostics			4	4	4	4	4
Subtotal	4		12.2	12.4	14.6	14.8	23
infrastr., extras(20%)							
TOTAL	**4.8**		**14.6**	**14.9**	**17.5**	**17.8**	**27.6**